almost tripled, which is the largest growth rate of any medical specialty in that period. This development has strengthened the standing of medical physics and radiation oncology in the hospitals. However, it has also been recognized that the growth in expenditure has not come with an increase in patient volume or corresponding outcome improvements. More recently the trend has reversed due in part to the overall economical situation and the healthcare reform. Cutting cost is the new theme. The research in medical physics has been hit particularly hard by this development. The budget and time for research is being cut. Funding from government agencies is increasingly harder to get. The trend to more "professionalism" in medical physics with mandatory physics residencies has shifted the focus further away from research.
In this presentation we will report on our efforts within the American Association of Physicists in Medicine (AAPM) Working Group FUTURE (FUTURE of Research and Academic Training) to put medical physics research back on the map. WG FUTURE activities include the definition of research activity roadmaps, organization of "Expanding Horizons" meetings to open doors for medical physics research outside of radiation oncology, support of students aspiring a research career in medical physics, and reaching out to similar activities elsewhere in the world.
We will also report on our own challenges of developing and maintaining a vibrant research environment in academic medical physics (at the University of Madison, Wisconsin) at in a hospital environment (Massachusetts General Hospital).

SP-0110
Medical physics research in a hospital department
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I would like to start by adding "small" and "clinical" to the title. It would then read *research in a small clinical Medical Physics Department*. Two things to define: research and small. Let's start with research. Research is "serious study of a subject that is intended to discover new facts or test new ideas". Small applied to a Medial Physics Department is more difficult to define but everybody would agree that a staff of 6 physicists, 6 RTT, 3 residents and 1 secretary to give service to Radiation Oncology, Nuclear Medicine, Imaging and Radiation Protection is not BIG. This describes the department in which I am working in. Now, the question: Can such a Department do any Research? And if so how this can happen? Four clues:
1. Optimize QA to get the time.Time is needed to think, to get inspired in order to choose the subject of your research.
2. Don't wait to see if you become BIG to start. It may never happen.
3. Link to other departments in the hospital, link to other Medical Physics departments in your city, departments at the Universities. This will enlarge your human resources and you will increase expertise in your group and also have different and interesting angles to your research topic.
4. Inspiration. Think outside the box. Take risks!
By doing this I think that you can study a subject and discover new facts or test new ideas. This is RESEARCH. It requires effort and enthusiasm, research is fun. Being small does not mean that you can't think BIG.

Symposium: Proton therapy II: state of the art

SP-0111
Dose calculation accuracy in proton therapy
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The number of facilities proton therapy is increasing around the world. The benefit of delivering radiation treatment with protons as compared to photons is the reduced integral dose due to the protons stopping inside the patient and delivering a high dose at the end of their range. This leads to highly conformal dose distributions with sharp dose gradients, both laterally as well as at the distal end of a proton treatment field. The distal high dose gradients make accurate dose calculations for proton therapy even more important than for photon therapy. A slight underestimation in proton range can lead to unirradiated sections of the target region.
Clinical dose calculations are generally performed using analytical algorithms, often referred to as pencil-beam algorithms, which propagate protons through the patient geometry. Each field is composed of 'pencils' which are separated into a central axis part combined with a Gaussian fluence map to account for the lateral beam spread. The main advantage of this approach is its computational speed. More accurate dose calculation algorithms such as Monte Carlo (MC) simulations are available but have not yet translated into clinical routine for proton therapy treatment planning due to lengthly calculation times. MC simulations are, however, frequently used to estimate the accuracy of analytical dose calculation algorithms.
Analytical algorithms generally fail to describe the effects of multiple Coulomb-scattering of protons. These effects are particularly important along high-density interfaces along the treatment field direction. Incorrect modeling of scattering can result in distortions of the delivered dose distributions. This can effect both the range of the proton field as well as the delivered dose distribution. Both effects will be discussed through comparisons between MC simulations and analytical dose calculations. We investigated the validity of range margins to compensate for range uncertainties and the clinical impact of dose calculation approximations.
In a site-specific analysis looking at 10-24 patients for 7 treatment sites, we find that for liver, prostate and whole brain fields a reduction of currently used uncertainty margins is feasible even without introducing MC dose calculations. Accounting for uncertainties from dose calculation algorithms we recommend a reduction of these margins to 2.8% + 1.2 mm for liver and prostate treatments and 3.1% + 1.2 mm for whole brain treatments, respectively. For some breast, lung and head & neck patients dose calculations current range margins are found to be insufficient, at least if used generically. We recommend a generic margin of 6.3% + 1.2 mm for breast, lung and head & neck treatments if no case specific adjustments are applied. Thus, currently used generic range uncertainty margins in proton therapy should be redefined in a site-specific manner and complex geometries may require a field specific adjustment.
For a dosimetric analysis of clinical used properties in a study containing 10 patients per site for 5 treatment sites, we find that target doses obtained with analytical dose calculation methods are, on average, 1-2% higher compared to those calculated with MC simulations. Both calculation methods agree within 5% for the mean dose, and the dose values covering 95%, 50% and 2% of the target volume. A γ-index

passing rate for target volumes was found to be above 96% for a 3%/3mm criteria. Differences in tumor control probability were within 2.5% for liver and breast, however, for head-and-neck and prostate patients the differences were up to 6.5% and up to 11% for lung patients.
We conclude that approximations introduced in analytical dose calculation methods can result in significant range uncertainties for heterogeneous patient geometries or introduce a systematically reduced dose in target volumes. Routine MC simulations for treatment planning or verification may be necessary to ensure full target coverage to the prescribed dose levels. In particular for clinical trials comparing photon vs. proton treatments, MC simulations may be required to avoid bias due to differences in dose calculations.

SP-0112
Proton beam monitor chamber calibration in clinical practice
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This talk describes the reference dosimetry of clinical proton beams. The main goal is to clarify the application of the IAEA TRS-398 dosimetry Code of Practice to modern proton beam delivery systems. A clear distinction is made between (i) those proton beam delivery systems that should be calibrated with an SOBP field, and (ii) those delivery systems that should be calibrated with a mono-energetic field. For these second type of delivery systems, a word of caution is issued on the use of cylindrical ionisation chambers. Contrary to the IAEA TRS-398 recommendations, this talk presents different arguments in favour of taking the effective point of measurement of cylindrical chambers into account when positioning the reference point of the chamber at the measurement depth. Finally, this talk also discusses the comparison between reference dosimetry and other independent dosimetry techniques, such as Faraday cup dosimetry and water calorimetry.

SP-0113
Myth and reality of image guidance and adaptive treatments in proton therapy
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The finite range of protons makes the delivered dose distribution, particularly in case of IMPT, very sensitive to any uncertainty and change in patient anatomy. In the best case, the patient anatomy and the treatment plans are robust over the entire treatment course such that treatment adaptation is not necessary. Adaptive therapy is, however, not simply a buzz-word, especially not for the relatively new indications for proton therapy in the thoracic and pelvic region. Existing and new proton therapy centers are working towards a framework that allows them to
1) determine which patients will benefit from a treatment adaptation.
2) efficiently adapt and validate the treatment plan.
The tools for such a framework are; volumetric image-guidance, dose-recalculation and accumulation, and plan-reoptimization. This presentation will discuss the needs for these tools, their availability and integration, and the current reality in plan adaptation in proton therapy.

Symposium with Proffered Papers: Advanced treatment planning techniques

SP-0114
Adaptive dose painting in head and neck
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The benefit of intensity-modulated radiation therapy (IMRT) in the treatment of head-and-neck cancer (HNC) has been demonstrated in numerous studies. Highly conformal radiation allows for a high dose to high-risk areas, whilst sparing adjacent organs at risk (OAR) such as the parotid glands. Clinical studies have shown that IMRT reduces grade-3 xerostomia in comparison to three-dimensional conformal radiotherapy. The next step is to develop dose-escalation studies, that so called “Dose painting”. Dose-painting IMRT is aimed at exploiting inhomogeneous dose distributions adapted to tumor heterogeneity. Tumor regions of increased radiation resistance receive escalated dose levels, whereas radiation-sensitive regions receive conventional or even de-escalated dose levels. Dose painting relies on biologic imaging. On the other hand, the changes to the dose distribution during treatment based on specific patients variations due to weight loss and tumor shrink must be corrected. For that purpose Adaptative Radiotherapy is developed. This is done by means of:
a) Image guided RT: Repositioning of the patient at the time of treatment
b) Dose tracking: Computiong fraction dose based on daily cone-beam CT, accumulating dose by deformable registration and evaluating the accumulated dose at different organs
c) Replanning: Adapt the dose to a systematic volumentric changes and compensate for undesired dose accumulation.
We will review the whole process and we will discuss the clinical data published and some of the new trials that are under evaluation.

SP-0115
Adaptive treatment planning in soft tissue sarcoma: Why and when is it necessary?
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Radiotherapy is an integral part of soft tissue sarcoma (STS) multidisciplinary management, with local control in excess of 90 % for disease arising in the extremities.
From our recently published *Phase 2 study of preoperative image-guided intensity modulated radiation therapy (IG-IMRT) to reduce wound and combined modality morbidities in lower extremity soft tissue sarcoma (LE-STS)*, approximately 20 % of the patient population required replanning during their course of radiation therapy (RT) due to soft tissue/tumour volume changes exceeding 1 cm as measured on daily cone beam CT localization used for RT guidance.
Previous work evaluated the dosimetric effect of tumour volume changes (TVC) for preoperative IMRT of LE-STS to determine critical indicators, as measured on daily CBCT localization, to motivate plan adaptation. We found that a 1 cm TVC deviation on CBCT imaging was a reliable threshold